DAMES & MOORE
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25 Kessel Court, Suite 201
Madison, Wisconsin 53711-6227
608 273 2886 Tel
608 273 3415 Fax

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Mr. Dave Crass
Michael Best & Friedrich
One South Pinckney
P.O. Box 1806
Madison, WI 53701-1806

RE: Gas and Tar Production and Release Estimates
Former MGP - NSP Ashland

Dear Dave:

This letter summarizes the results of our research into the operation and production of manufactured gas and tars at the former LSDP manufactured gas plant (MGP) facility in Ashland, Wisconsin. Information is presented that substantiates the gas production for each year of operation from 1885 - 1946, the likely quantity of tar produced in from the manufacturing process, and the quantity of coal tar product residue measured in the environment near the former MGP and near the former Schroeder Lumber operations.

I. Gas Production

Historic Operating Reports

In our March 2, 1998 letter to the WDNR, we computed a total gas production quantity of 1,371,968 mcf of gas produced at the plant during it's 62 year operating life. This was based primarily on data provided following NSP's review of Brown's Directories of Gas Statistics on American Gas companies for the years 1899 - 1947-48. In that letter, for those years where data was unavailable (as for years 1885-97), we assumed an annual gas production quantity equal to the first year's reported data (1898). For other years where data was missing (1899, 1915, 1939) a gas production volume was interpolated from previous and subsequent years' data.

To refine these calculations, we reviewed the further documentation you provided. Documents reviewed included Brown's Directories for all years between 1899 and 1947-48 (corresponding to production years 1898 - 1946), and LSDP annual operating and financial reports to the Railroad Commission of Wisconsin (for several years prior to 1923).

The results of these reviews are summarized on the attached table. Unlike the previous study described in the March 2 letter, gas production data from Brown's was available for 1899 and 1939. Additionally, data was available for production years 1908, 1921, 1922, 1931-1933, 1938-1939, and 1944 which was not previously reviewed. For comparison purposes, annual records for each registry are shown. Note that for each entry where both records are available, the values are either identical

or nearly so. The only year for which values differ significantly between the two is for 1908, which is the first year for which LSDP data are is available. For this year, Brown's reports the same value as that for the previous year. Note that this same result occurs in 1932 and 1938; the Brown's data in those years are is the same as the previous year's reported value. Consequently, LSDP values in lieu of Brown's values were used for those years.

This more complete database yields a total gas production quantity of 1,392,496.70 mcf over the life of the MGP. This value compares to a total volume of 1,371,968 mcf reported in the March 2 letter, an increase of 20,528.7 mcf, or less than 1.5 percent of the value computed in the March 2 letter.

Sales Versus Production Quantities

The March 2 letter was prompted by a WDNR letter of February 20 (and amendment of February 24) which computed a total quantity of 1,562,961 mcf. This was based on one year of gas production data in Brown's (1935), as well as one year of earlier NSP data (Dames & Moore, March 1995), that reported several years of gas sales versus gas production quantities. The WDNR's total gas production volume assumed a 13 percent differential between gas production and gas sales data for all years as reported in the March 1995 report. This difference was based on the 1935 Brown's information. Although gas sales data were used for some of these years in the earlier report, the Department's estimate was flawed because this assumption was applied to the entire plant operating life. This revised estimate of 1,392,496.70 mcf is considerably more accurate because it is based on contemporaneously reported production data.

II. Tar Production

Background

The above total gas production volume estimate is important because of the bearing it has on the total tar quantity produced over the operating life of the MGP. Our March 2 letter provided a total tar production value of 602,294 gallons during the plant life, based upon an average ratio of 0.439 gallons tar/mcf of gas produced. This ratio was arrived at by comparing the total gas produced against the total tar produced for those years (1939, 1941 and 1944) for which both values were recorded. Our recent research did not yield additional tar production records. Consequently, we evaluated the gas production processes used at the MGP in conjunction with published tar-to-gas ratio data references to validate our earlier tar production estimates.

Gas Production Processes

The gas production process utilized at the MGP is listed in the Brown's Directories, and is shown in the second column of the attached table. The Brown's Directories identify changes in the plant's gas production processes that appear to be variants on the Lowe process, first reported from 1898 to 1901. For example, from 1902 to 1908, the method listed is *Moses(water)*, and then from 1909 to 1911 is *Lowe(Moses)*. From 1912 to 1916, the method named is *Oil*, followed by *Oil and Coal* through 1920, where in turn the method is listed as *Water Gas* through 1946.

Our March 1995 report presumed that the plant manufactured gas using a carbonization process until 1920, when the process was changed to gasification. Carbonization was the conventional coal gas process, and gasification resulted in carbureted water-gas (CWG). Based on what has been recently reviewed, we now believe the plant operated as a CWG plant during its entire life.

As shown, several process changes occurred at the Ashland MGP after production methods first were reported in 1898. Nothing specific about the first reported method (Lowe) is known; however, USEPA[1] (1988) identifies Lowe as the inventor of CWG in 1875. It is also important to note that when LSDP operating report data for years after 1908 was recently reviewed, the manufactured gas process reported is water gas, not coal gas. LSDP operating reports show standard ledger sheets with coal gas input values blank, whereas water gas values for all years except 1917 are the same as those entered for total gas production values. This indicates that for all years except 1917, water gas was produced.[2]

[1] *U.S. Production of Manufactured Gases: Assessment of Past Disposal Practices*, USEPA, Research Triangle Institute, Research Triangle Park, NC, 1988.

[2] The one exception is for 1917, when a small portion of the total gas production stream that year (less than 15 percent) is reported as coal gas. However, subsequent years again indicate only water gas production. Note that from 1913 through 1916 Brown's reported that the Ashland MGP "will construct coal gas plant of 14,000,000 c.f. (i.e., 14,000 mcf) capacity per annum." From 1917 on, there is no mention of this coal gas operation in the Brown's Directories. (Note also that Brown's reported only gas sales data from 1909 through 1920. Because LSDP data was available for this period, this information was utilized in our estimates.

The Carbureted Water Gas Process

USEPA indicates that two materials were needed for CWG production: solid carbon and liquid hydrocarbon (see USEPA, page 34). Through World War One, the common source for the solid carbon was anthracite (coal) or coke from bituminous (coal). After WWI, process changes prompted by increasing anthracite costs enabled some plants to burn bituminous directly. (All plants did not convert, however, because many had coke production ovens on site.) USEPA reported that the preferred source of the liquid hydrocarbon was naphtha, a light-weight crude fraction. However, more plants used a heavier fraction called gas-oil after 1895. The increased demand for gasoline after 1930 (a fraction of gas-oil) prompted the MGP industry to convert to yet heavier fuels (i.e., heavy fuel oil). USEPA (1988, pg. 125) indicates that these conversions to heavy fuel oils "were better absorbed by larger plants," since tar quantities increased by as much as 25 percent. Conversion to heavy oils was resisted by smaller plants principally because of operating cost. Based on the above and the tar generation data reviewed, it is our conclusion that for the Ashland plant employed the oil-gas CWG process throughout its operational life.

Tar Production at the Ashland Plant

For the three years for which tar production is reported, Brown's also reports the quantity of gas oil used and the quantity of bituminous used as a water gas generator. USEPA reports (Table 35) that for oil gas feedstocks in CWG systems, the quantity of tar produced per gallon of oil feedstock used yielded ratios of 0.16 to 0.18. For these three years the actual ratios based on reported data were 0.20 for 1939, 0.13 for 1941, and 0.14 for 1944, for an average of 0.155. This falls within the range given in the USEPA report. (Table 35 presents a tar to oil feedstock ratio of 0.23 for heavy fuel oil CWG systems, with a tar generation estimate of 800-1,000 gallons produced for each mcf $\times 10^3$ gas produced. Note that this tar to feedstock ratio is too high for any of the years for which data are reported for the Ashland plant, indicating heavy fuel oil was not used.)

Table 35 in the USEPA report also indicates that for these CWG oil gas processes, from 470-640 gallons of tar were produced for each mcf $\times 10^3$ gas produced (or 0.470 - 0.640 per mcf as we reported in the March 2 letter). This is a separate ratio from that provided for the tar to feedstock ratio, and compares to the 0.439 ratio we used in the March 2 letter. The tar generation values presented in this letter and shown on the attached table for each year of operation assume this same 0.439 ratio.

Based on the foregoing, we conclude:

- The MGP originally implemented and then maintained with some variation a CWG process, and oil gas was the predominant liquid feedstock throughout the entire plant life.
- Coal gas (as manufactured in the carbonization process) was never a major product, manufactured briefly during 1917, and constituted only 15 percent of that year's production.
- The tar production ratios the Department used in its their February 20 and 24 letters for the time periods before and after 1918 are completely erroneous.[3]
- Applying the 0.439 ratio to the "revised" total gas production quantity yields a total of 611,306 gallons of tar produced during the plant lifetime. This compares to the 602,294 gallons tar produced described in the March 2 letter, an increase of only 1.5 percent.

A final point on the assumed CWG process at the Ashland site during it's operating life needs to be mentioned. Although only a few samples have been analyzed, cyanides have not been detected at the site. USEPA reports that CWG tars "contain many of the compounds present in coal tar, but they contain no tar acids (phenolics) and only traces of coal nitrogen compounds...(consequently) very small amounts of ammonia and cyanide appeared in the gas from (CWG) operations, and this is reflected by low concentrations of these compounds in byproducts." This is further support for our conclusion that the Ashland plant operated as a CWG plant.

III. Product Estimates Present in Bay Sediments and the Copper Falls Aquifer

Product Present in the Bay Sediments

The March 2 letter provided an estimate of more than 2,000,000 gallons of residual tar product present in the sediments, based upon the data and analysis of the sediments provided by SEH in its July 1996 report. That data indicated that the most contaminated area of sediment covered an area of about 7 acres at an average depth of six feet. To compute this quantity, a porosity value of 0.3 (volume of void/total volume) was assumed. Also, high levels of VOC and PAH contamination (concentrations as high as 1000 mg/kg) indicated the presence of pure product. Accordingly, we assumed that 50 percent of the available void space was occupied by residual product, resulting in

[3] The Department assumed coal carbonization-horizontal gas retort production methods prior to 1918, and used an average tar production ratio of 0.955; for the period after 1918, they assumed an oil gas CWG process, and used 0.555. These values were taken as averages for these methods presented in the USEPA Table 35 described above, and are not based on actual production records.

a quantity in excess of 2,000,000 gallons. SEH calculated a range of 39,000 to 583,000 gallons of tar present in the bay sediments and soils at Kreher Park. A critique of these estimates is attached to this letter.

Product Present in the Copper Falls Aquifer

The final estimate presented here of tar in the environment is the product volume currently present in the Copper Falls aquifer. The quantities needed to determine this mass are the thickness of dense non-aqueous phase liquids (DNAPL) measured in wells screened in the Copper Falls, and an estimate of the aerial extent of the DNAPL mass. In our Remedial Action Plan for the Lower Copper Falls Aquifer (Dames & Moore, April 1998), we described an elliptical DNAPL plume approximately 350 feet by 170 feet in plan view. The greatest thicknesses of DNAPL has been measured in well 13B on St. Claire St., at thicknesses varying from 13.5 to 16.5 feet. The intermediate well 13A in the same well nest has yielded approximately 2 feet of DNAPL. A well on the leading edge of the plume (7A) has yielded samples with high contaminant levels, but not at levels to indicate DNAPL (DNAPL has not been measured in this well). The other wells screened in the Copper Falls Aquifer are beyond the flanks of the plume.

The release point of the coal tar product that formed the plume is likely in the area of the extraction well EW-1. At this location, the plume is thickest (near 13B), but likely thins to the north in the direction of groundwater flow. Based upon this limited data, an approximate thickness of two feet is assumed for the DNAPL area shown in the RAP. The approximate area of the ellipse is 50,000 square feet. This translates to a volume of 100,000 cubic feet. At a porosity of 0.25 for the Copper Falls, the volume of DNAPL present is 25,000 cubic feet, or 187,000 gallons. Recognize that this estimate has a potentially high error margin because of the limited data.

THEY HAVE ABSOLUTELY NO IDEA!

Further Product Adjustments

For the three years for which LSDP operating data on tar generation is available (1939, 1941 and 1944), the same records indicate that 19,034, 10,000 and 17,814 gallons of tar, respectively, were sold. Additionally, approximately 7,000 gallons of tar product residual from the former MGP were disposed in 1993 when a concrete tar reservoir was excavated from the NSP property and disposed off site. This totals nearly 54,000 gallons. Assuming that the Copper Falls estimates above are off by 25 percent (i.e., only a total of 140,000 gallons are present), nearly 200,000 gallons, or approximately one-third of the 611,000 gallons generated during the life of the MGP, are <u>not</u> present in the sediments. The remaining 400,000 gallons fall significantly below the 2,000,000 gallons previously shown present in the sediments. For these comparisons, no other reduction in tar volume

is assumed for any unreported tar sold, or burned as boiler fuel[4], since no other records exist. The reported tar volume sold (46,848 gallons) constitutes about 7.5 percent of the total tar production volume. This compares to the 1984 Radian study [5] which reported that, on average, 76 percent of all tar generated from MGPs nationwide was sold as a by-product.

IV. Conclusion

The calculations presented in this letter confirm that contamination in the sediments cannot be restricted to releases of tar from the MGP. As described in previous documents, much of the plant's tar was reburned as boiler fuel and sold/recycled as a product. The total tar production of approximately 611,000 gallons during the MGP's lifetime is not sufficiently large to account for the volume of residual tar present in the environment. The volumes currently present in the offshore sediments and soils at Kreher Park are too large, and the concentrations too high to have originated solely from the former gas plant.

This summarizes the results. Please call with any questions.

Sincerely,

DAMES & MOORE

David P. Trainor
Principal

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[4] USEPA (1988) reports that "the principal use of CWG tars was as a fuel. The CWG tars could be burned in the plant boilers, replacing the coal that would normally have to be consumed. (These) tars...would be burned if they could not be sold for a price that exceeded the fuel value of the tars."

[5] *Survey of Tar Waste Disposal and Locations of Town Gas Producers*, Radian Corporation, Austin, TX., 1984